And the DAC cell is fine tuned to the non-linear value according to the sinusoidal waveform. The positive and negative frequency of f3 is depended on the positive and negative summation operation of the channel selection control bits in FIG.6. The frequency summation operations are based on dual inputs balanced mixer or triple inputs balanced mixer as shown in FIG.7 shown in CMOS topologies. With the above preferred circuit embodiment implementation, they can be applied in direct conversion, low-IF and high-IF transceivers as sown in FIG.8 FIG.9 and FIG10.

The invention can be used as a single carrier fc frequency synthesizer for not only a single standard multi-mode device but also multi-mode and multi-standard device as shown in FIG. 1 according to the frequency plan in Table.1 such as a combo IEEE802.11a/b/g, Bluetooth, WCDMA, CDMA dual-band, GSM quad-band, and GPS transceivers. The channel switching time is almost zero in this frequency synthesizer architecture. It can also be used as multiple ports frequency synthesizers in not only a single standard multi-mode communication system but also multi-mode and multi-standard system by adding more f3 frequency generators without adding more f1 and f2 frequency generators as shown in FIG. 11. The f1=5280MHz frequency generator can also be used with constant frequency generators for generating the 11MHz,22MHz,44Mz,88MHz clocks for the IEEE802.11b/g and cable modem applications. That is, this frequency planning and frequency synthesizer architecture is also fit for a broadband gateway or routers with wireless links. By this invention, the frequency synthesizer design can be very compact and cost-effective in various communications networking systems.

Although the present invention has been described in detail with reference to the preferred embodiments thereof, those skilled in the art will appreciate that various substitutions and modifications can be made to the examples described herein while remaining within the spirit and scope of the invention as defined in the appended claims.

Claims

I claim:

1. Apparatus for transmitting and receiving signals that is in conformity with a communications standard or among multi-standard and comprises a carrier signal modulated by a wanted signal, said communications standard defining a plurality of communications channels having central frequencies that are separated from one another by a fixed frequency referred to as a channel spacing, the modulated carrier signal occupying one of said plurality of communications channels, the apparatus including the first high frequency(HF) PLL 103 to generate f1 and f2 at an actual local oscillator frequencies which differs from said central frequency of the channel occupied by said wanted signal by a frequency difference f3 whose frequency is generated by a programmable mixed-signal waveform generator 104 followed with Digital to Analog Converters (DAC) and a filters. The mixing operation can be up conversion or down conversion.

For up conversion f_up=fa+fb it is generated by cos(2*pi*f_up*t) = cos(2*pi*fa*t) * cos(2*pi*fb*t) - sin(2*pi*fa*t) * sin(2*pi*fb*t). and sin(2*pi*f-up*t) = sin(2*pi*fa*t) * con(2*pi*fb*t) + cos(2*pi*fa*t) * sin(2*pi*fb*t).
For down conversion f_down=fa-fb,it is generated by cos(2*pi*f_down*t) = cos(2*pi*fa*t) * cos(2*pi*fb*t) + sin(2*pi*fa*t) * sin(2*pi*fb*t) and sin(2*pi*f-down*t) = sin(2*pi*fa*t) * cos(2*pi*fb*t) - cos(2*pi*fa*t) * sin(2*pi*fb*t).
The transmitter 107 mixes the transmitted data signal and the final carrier frequency signal produced by mixing f1,f2 and f3 frequency signals, that is fc=((f1+f2)+f3), from the GRFS in FIG 1. The receiver 108 can be in direct conversion receiving or multi-stage down conversion by the frequency plan defined in this invention as shown in FIG2 and FIG3. or claim2. And multiple transceivers in different carrier channels can share the same f1 and f2 frequency generators in a communication system like multi-port WLAN switch or hub access points as also shown in FIG.1 .

2. A method according to claim 1 wherein the operation as shown in Table.1
For example, a direct conversion operation as shown in FIG. 2 , IEEE802.11a WLAN f1=5280MHz, f2=0 and f3=-100MHz to 40MHz with 20MHz step for lower 5GHz band (5180MHz:20MHz:5320MHz) and f1=5940MHz , f2=0 and f3=-195MHz to -135 MHz with 20MHz step for upper 5GHz band (5745MHz:20MHz:5805MHz).
For IEEE802.11b/g WLAN (2412MHz:5MHz:2472Mz), f1=2420MHz, f2=0, f3=-8MHz to 52MHz with 5MHz step for IEEE802.11b and 20MHz for IEEE802.11g , the 11MHz baseband digital clock is also generated by 5280MHz/480. For IEEE802.11b multistage low-IF receiver, f1+f2+f3=fc-22MHz as shown in FIG.10 , the 22MHz difference is processing by digital mixer operation with a 88MHz clock from 5280MHz/60. The same low-IF approach can also applied to other wireless communication standard in the innovative frequency planning and synthesizer design. Since, the transceiver and base-band is WLAN oriented, the circuit blocks in transmitter and receiver paths such as data converters and DSP processing power in base-band are good enough to handle all the communication standard listed in table1. That is this frequency planning and architecture of the general radio frequency synthesizer can be applied in direct conversion and low-IF and high-IF transceiver architectures. Therefore, this invention can be a general radio frequency synthesizer for current and future wireless communication standard.
For Bluetooth (2402MHz:1MHz:2480MHz), f1=2420MHz, f2=0MHz and f3=-18MHz to 60MHz with 1MHz step.
For WCDMA (1920MHz:5MHz:1980MHz), f1=1980MHz, f2=0MHz and f3=-60MHz : 5MHz:0MHz
For WCDMA (2110MHz:5MHz:2170MHz), f1=2090MHz, f2=0MHz and f3=20MHz : 5MHz: 80MHz
For multi-stage operation with a central 660MHz Band Pass Filter (BPF) as shown in FIG.3 or in Table 1, the positive and negative sign operation of f2,can also be decoded by the base-band signal processing. The f3 frequency range is for current carious wireless communication standard, it can be extended to several hundred mega hertz and the resolution can be changed by the apparatus shown in FIG.6 to meet next generation wireless standard requirement.

3. A method and apparatus of single frequency generators according to claim1 is shown

in FIG. 4. For 5280MHz, it is generated from a 20MHz crystal 401 reference signal with quadrature VCO 405 circuits to produce HF f1 signals I,Q. For minimizing phase noise for some communication standards like IEEE802.11a/g OFDM system, the frequency tuning of the PLLs' charge pump 404 are disabled during transmitting or receiving data packets. Innovative Superharmonic Quadrature Injection-Locked Frequency Dividers as shown in FIGS. 5 are invented to produce a single constant frequency analog division operation with IQ quadrature outputs. The divider can also be implemented by a frequency divider with poly-phase filters to generate the IQ quadrature phase outputs.

4. A method and apparatus of mixed-signal frequency generator is shown in FIG6. The channel spacing is controlled by the frequency resolution control bits to choose the DAC sampling frequency and the channel spacing input bits for the input of modulo-counter/adder 601. The sampling clock can be from the output after the constant divider of f1 or f2 PLL for different communication standards. The non-linear DAC is sinusoidal waveform shaped. They share the same DAC ladder block 604 with I,Q sample and hold circuits followed by low pass analog filters 605 ,606.

5. A method and apparatus of mixer in claim 1 is Shown in FIG. 7. A two-port double balanced mixer of up-conversion or down-conversion is defined in claim 1. The mixer can also be implemented by a multiplier with image rejection filters or band-pass filters. Three input port mixer operations can be a cascade of two two input port mixer or integrated in one circuit as triple balanced mixer shown in FIG6.

6. A method and apparatus for instant/simultaneously channel switching is then be achieved according to claim1-5.

7. A method and apparatus for minimize the phase noise of oscillator is also provided in by fine tuning a single frequency oscillator instead of tuning over the extension range of VCOs in traditional frequency synthesizer with programmable counters frequency dividers. Since the two main f1 f2 are constant frequencies, the low power dividerless PLL frequency generator with aperture phase detector can also be applied in this frequency synthesizer architecture.

8. A method and apparatus for accessing multi-mode wireless communication is achieved by switching the f1,f2, and f3. For example, from IEEE802.11a to IEEE802.11b, f1 is switching from 5280MHz to 5280MHz/3+660MHz. And the channel frequency is selected by changing f3. By the same method and apparatus, this invention enables the channel carrier frequency fast switching from one standard to another one, by select the f1,f2, and f3 according to table.1 . And f1 and f2 are the outputs of the constant dividers of fine tuned single frequency source. More than one communication standard can also be simultaneously achieved by adding more mixed-signal waveform generator and mixers to provide another carrier frequency without adding more the main RF PLL frequency generators to reproduce f1 and f2.

9. A single frequency synthesizer design method and apparatus is then provided to enable a base-station or mobile station to meet multi-port wireless communication networking

operation by adding more mixed-signal frequency generator f3s without adding more f1 and f2 PLL frequency generators to save BOM cost and power consumptions. With the same method, the invention also enables the apparatus to provide carrier frequencies in multi-mode or multiple standards simultaneously in the cost effective frequency synthesis solutions. And the 11MHz*N,N=1,2,4,8,... for IEEE802.11b/g and cable modem bae-band clock can be generated from the 5280MHz VCO by the constant frequency dividers. Therefore, this invention is also suitable to be applied in a broadband gateway or router systems with wireless links.

10. Method and apparatus apply not only the standard in claim2 or table 1. but also for current others communication standard and the future next generation communication standards.

11. The mixed-signal waveform generator in claim 4 can also be a summing of multiple frequency generators to enable the broadcast function in wireless communication network. The compact version of multiple frequencies generator is a FFT professor. The f3 mixed-signal waveform generator can also be replaced by a traditional direct digital frequency synthesizer. The frequency range of f3 is not limited by table1. The range can be extended by modifying the design in FIG.6.

12. The claim of the frequency synthesizer for multimode and multi-standard wireless communication can be any combinations of the communication standards in claims 2 / Table 1 and claim 10.

Unit:MHz	f1 : Direct Conversion Multi-stage	f2	f3
IEEE802.11a Lower 5G Band 5180:20:5320	5280 4620=5280-660	0 660	-100:20:40
IEEE802.11a Upper 5G Band 5745:20:5805	5940=5280+660 6600=5940+660	0 -660	-195:20:-135
IEEE802.11b/g 2412:5:2472	2420=5280/3+660 3080=2420+660	0 -660	-8:5:52
Bluetooth 2402:2480	2420 3080	0 -660	-18:1:60
WCDMA BS:1920:5:1980 MS:2110:5:2170	1980=5280/4+660 1320=5280/4	0 660	-60:5:0
	2090=5280/3+660/2 1430=5280/3-660/2	0 660	20:5:80
GSM Quadband 869-894	880=5280/6 1540=880+660	0 -660	-11 : 0.2 : 14
925:960	880 1540	0 -660	45:80
1805:1880	1870=5280/3+660/6 1210=1870-660	0 660	-65:10
1930:1990	1980=5280/4+660 1320	0 660	-50:10
824:849	880 1540	0 -660	-56 : -31
880:915	880 1540	0 -660	0:35
1710:1785	1760=5280/3 1100=1760-660	0 660	-50:25
1850:1910	1870=5280/3+660/6 1210=1885-660	0 660	-20:40
CDMA Dualband celluar 824:925	880 1540	0 -660	-56:45
PCS:1750:1980	1870 1210	0 660	-120:110

Table 1. Frequency Plan of frequency synthesizer and transceiver for wireless communication networking systems.